Eyles

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Apollo Project Memo #18-69

TO: Distribution
FROM: George W. Cherry
DATE: 19 February 1969
SUBJECT: Decisions of the 29th Apollo Spacecraft Software Configuration Control Board Which Affect LUMINARY 1A

The 29th SCB meeting was held on 18 February 1969. Norm Sears and I represented MIT. Immediately after the LM items were covered, I left to return to Cambridge and so Norm will have to cover the outcome on the CSM items.

For those who are interested in software development statistics, I have the following summary: 10 PCRs and 2 PCNs concerning LUMINARY 1A were discussed; 7 PCRs were approved for a summed impact of 6 days (making our MIT internally controlled release date 25 March 1969); 3 PCRs were disapproved (they would have had an additional summed impact of 18 days); and the two PCNs were, of course, approved.

I am very pleased with the PCRs which were approved. They are operationally very, very desireable if not downright mandatory. The G mission commander and LM pilot were very enthusiastic in particular about PCR 737 (described below) and instrumental in its generation (although I am the originator of record). PCR 737 is, in effect, the "one more PCR in the lunar landing area" which I promised (threatened?) Mr. Kraft he would be seeing at his next SCB when he was at MIT last week.

Seven PCRs sound like a lot so close to release date; but several of them are trivial to implement; one is merely a clarifying re-write of a previously approved baseline PCR; and one has already had a paid-for detailed change evaluation. Furthermore, I would be very surprised if any more mandatory changes were lurking in the wings. New PCRs for LUMINARY should mean PCRs for LUMINARY 1B.

Approved PCRs

PCR 268.2 Reduction of P34/P35
Run Time (Impact = 2 days)

I explained the mechanization to the board which Dan Lickly had explained to me and they bought it. (I had asked Dan to make the detailed change evaluation.) The salient points of the mechanization are the following:

1. R1 in N55 (R1 is normally the number of apsidal crossings but in the present GSOP it is blank when N55 appears in P34) comes up 0 (zero) indicating zero precision target offsets. If the astronaut wants N precision target offsets he enters N in R1. For lunar orbit concentric flight plan rendezvous, MPAD and we have established that N=0 is okay -- that means conics only. But for earth orbit rendezvous he could specify N=1 or 2.
2. Whatever the astronaut chooses for N in P34 goes for P35 also.
3. P38/P39 would continue to use precision integrations to determine the target offset (which, if you read the title of the PCR, sure makes sense).

MSC wanted this change very earnestly to save time in the astronaut's crowded time-line.

They wanted it just as badly in COLOSSUS.

Action: Dan, please assign someone to change and test LUMINARY 1A. Walker Kupfer, Bill Marscher, and Wayne Templeman please prepare change pages as soon as possible for LUMINARY 1A GSOP.

- PCR271 Downlink Change (0 impact)

I like the really illuminating title of this PCR. Why didn't they call it "Replace VGTIG With RLS on LUMINARY Coast/Align Downlist"

Action: Craig Schulenberg, please change the program.
Bob Tinkham, please change Section 2.

- PCR700A Improve the Rate-of-Descent Mode (P66) Performance (baseline)

This is just a clarifying re-write of PCR700. The action has already been assigned. But I would appreciate someone in Bill Widnall's group looking at the idea for lag compensation that Craig is putting in. Bill . . . ?

- PCR723 Two-Segment LR Altitude and Velocity Weighting Functions (Impact = 1 day)

This was not approved precisely as Don Gustafson wrote it. I recommended that the board approve it with the Altitude weighting function change request deleted and a change added to permit P65,66,67 to establish a new weighting function value for velocity. We visualize a very small value established by P65. The board approved the amended PCR.

Action: Bernie and Don, please determine, in the language of PCR723, what values should be used for V_f, W_{vfi}, and W_{vi} when P65 establishes the velocity weighting function and please update GSOP Section 5.
Bob Covelli, Craig Schulenberg, Bernie, Don, let us have a design review on the implementation of this today or early Thursday.

- PCR732 Permit the Crew to Modify W-Matrix Bias Error in V67 Routine (Impact = 1 day)

The bias error, displayed and loaded in R3 of N99, should be scaled in milliradians. And let's keep factors of $1/\sqrt{2}$ out of this.

We have an action item to investigate making N99 units easier for the astronaut to use. If there is no schedule slip for scaling position uncertainty in feet we should make this change in both COLOSSUS and LUMINARY. Also, we should eliminate the division by $\sqrt{3}$ in the program so that the astronaut does not have to multiply the number he loads by $\sqrt{3}$.

(Incidentally, I believe it is desirable to display the erasable initialization values in N99 initially rather than the current values in the W matrix. This saves all the coding and storage used to compute the N99 display from the W matrix elements and the required check for display overflow. I think that the current N99 display (until it is loaded with new initialization values) is strictly a "Gee Whiz!" display. But displaying the currently used erasable initialization values is both simpler and more informative. I will write a PCR for this change.)

To sum up, the preferred scaling is

N99

R1	position uncertainty (1 ft)
R2	velocity uncertainty (0.1 ft/sec)
R3	bias uncertainty (1 milliradian)

Action: Dan, please coordinate these changes between the two programs. Repeating, the ground rules are to simplyfy the load scaling while keeping the programs alike and avoiding addition schedule impact.

- PCR736 Add Source Code to Noun 49 in P20/P22. (Impact = 1 day)

When a navigation measurement (range, range rate, shaft or trunnion angles) would cause an excessive update to the state vector, the following display appears

FL V06 N49
R1 - DELTA R magnitude of position correction
R2 - DELTA V magnitude of velocity correction
R3 - Blank

and the crew (in the spacecraft or the LMS) does not know which measurement is causing the large intended state vector change. Bob's PCR puts a source code in R3 to tell the crew (1 = range, 2 = range rate, 3 = shaft angle, 4 = trunnion angle) which measurement caused the display.

Action: Peter Volante or Virginia Dunbar, please prepare the program change.
Bob White, please prepare the GSOP changes.

PCR737 Permit ATT HOLD Mode in P63, P64, P65. (Impact = 1 day)

Neil Armstrong and Col. Aldrin really liked this one. Neil dropped in on the SCB to make sure, I think, that it got in. He said that this PCR and the new trajectory which MPAD and MIT (Jim Alphin and Allan Klumpp) came up with last weekend, are the two most outstanding handles on the lunar landing to come up in many months. Allan has done a fine job on his targetting program and target generation efforts.

Kraft announced during the meeting that the trajectory presented to the G crew and others on Monday was official. Salient features of this trajectory are

ΔV = 6711 ft/sec for a fully automatic landing
low-gate alitude = 150 feet
Sink rate at 500 feet altitude = 15.5 ft/sec
Switch to P64 when T_{go} = 60 in P63.
Switch to P65 when T_{go} = 10 in P64.

This trajectory, along with PCR737, makes it much more probable that the crew will stay with LGC automatic guidance until, or at least closer to, lunar touchdown. For example, if Neil switches to ATT HOLD at 500 feet altitude, P64 will automatically reduce the vehicle sink rate since the nominal automatic trajectory would keep reducing the sink rate (to about 7.5 ft/sec 35 seconds later, for example)

We might want to establish some guidelines for permissible attitude error while the LM commander is testing the ACA and assessing the LM handling qualities.

Since PCR737 was an MIT walk-on and not many have seen it, I am attaching it.

Action: Don Eyles, Craig Schulenberg, please change the program.
Bernie, Walker, please produce the GSOP candidate change pages.

Approved PCN's

PCN688 Guidance Frame Erection Check

PCR731 Modify the Lunar Landing Guidance Equations to Compensate for Computation and FINDCDUW Lags

I think that these PCRs are self-explanatory. The action has already been assigned and carried out.

Disapproved PCR's

PCR??? Modify the LR Read Routine R12 to Compensate for Radar Velocity Biases.

This was not really an official PCR but Mr. Kraft asked me about it. I told him that it would cost about two days to subtract some number from each averaged set of velocity readings and that I heard that this was not as good a fix as the hardware fix. Chris said that the decision was already made to fix the hardware but he wanted to hear about the effect of the software change anyway.

PCR273 Revised Radial Jerk Limits for P12, P70, P71
(Impact = 8 days)

Eight days because they wanted to move the jerk limits into erasable, and erasables for P12 are scarce! And the abort area is a long pole in the tent. Bill Tindall is supposed to give us

the best jerk limits (probably 0.2 rather than 0.1) by Friday and we will change the fixed register value before we complete our tests. There's some problem here with compatibility with the AGS. I won't go into it.

PCR274.1 Modification of Lunar Potential Function (8 days)

I expect that this is a good candidate for LUMINARY1B. Boeing's R2 model is a solid improvement over the triax model but the RTCC would probably try to correct the remaining error anyway. Now their procedures will have to correct the whole error since the PCR was turned down. Chris does want us to do some work on the side on this -- mainly to make sure that we get it into LUMINARY1B, I think.

MSC's proposal was to do at <u>least</u> <u>one</u> of the following:

1. Add necessary formulation to include the J_{31} term.
2. Put all coefficients (J_2, J_3, J_4, J_{22}, C_{31}) in erasable memory.

Action: Bill Marscher, would you please have someone look into this. Perhaps it could go into the LM and CSM G programs if the required release dates change.

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